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Exploring Design Patterns as Evaluation Tools in Human Computer Interaction Education

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ABSTRACT

In Human Computer Interaction (HCI), interest in design patterns and pattern languages has continued for decades. There are many potential benefits of design patterns and pattern languages described in the literature including reuse of quality solutions, providing a lingua franca, and their application as both design and evaluation tools. However, there is still a lack of empirical evidence in this area. Many of the questions and concerns raised in this area have yet to be addressed. Dearden and Finlay in their 2006 critical review provide an agenda that includes exploring appropriate ways to use pattern languages in education and design. This work explores the use of design patterns in HCI education and the use of design patterns as evaluation tools. The results of this exploration suggest that design patterns may be an effective tool to educate novice designers and design patterns may be useful in evaluating designs.

Keywords (Required)

Design patterns, education, evaluation, heuristics, Human Computer Interaction, pattern languages.

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INTRODUCTION

For several decades interest in patterns and pattern languages in HCI has continued. This interest is visible in books, panels, papers, pattern libraries, websites, and workshops (Pan and Stolterman, 2013; Tidwell, 2006; Vora, 2009). There are many proposed benefits of design patterns and pattern languages described in the literature. These benefits include, among other things: reuse of (quality) solutions, improved communication (Pemberton, 2000) and the use of patterns as both design and evaluation tools (Borchers 2001; Mahemoff and Johnston 1998; Wesson and Cowley, 2003). Problems with patterns have also been discussed in the literature. Problems include, among other things: lack of a standard format (Seffah and Javahery, 2002), lack of an organizing principle (Fincher, 1999; Fincher and Windsor, 2000; Welie and Veer, 2003) and lack of empirical work to support the proposed benefits (Dearden and Finlay, 2006). Dearden and Finlay (2006) in their critical review outlined a research agenda including four areas. One area identified by Dearden and Finlay (2006) is exploring ways to use pattern languages in education and design. Some have explored ways to use design patterns in education (Borchers, 2002; Koukouletsos, 2009). Some have conducted controlled experiments (Saponas, Prabaker, Abowd, and Landay, 2006). Others have documented use in the wild (Malone, Leacock, and Wheeler, 2005). Gathering empirical data in design disciplines can be challenging for many reasons including: access to designers and usability engineers, limitations of controlled experiments (specifically related to design), and difficulty conducting studies in the wild. Some empirical work has been completed, however, more is needed. Related work is summarized in the next section. Due to page limitations the discussion of related work is limited.

RELATED WORK

Patterns and pattern languages have been discussed, documented, researched and applied in HCI for several decades. Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, and Angel (1977) introduced patterns and a pattern language, for architecture in a book titled: *A Pattern Language*. This book is one of three volumes in a series published by Alexander and colleagues (Alexander et al. 1977, Alexander et al. 1979; Alexander, Silverstein, Angel, and Abrams, 1975). Patterns and pattern languages have been documented in many of disciplines outside of architecture, including but not limited to software engineering (Gamma, Helm, Johnson, and Vlissides, 1994) and HCI (Dearden, Finlay, Allgar, and McManus, 2002; Dearden and Finlay, 2006). In HCI and software engineering much of the work has focused on the capture and sharing of patterns, pattern libraries and pattern languages. Alexander (1977) describes that the intention of a pattern language in architecture is to capture the heart of solutions to recurring design problems and provide a process and a language that architects and non-architects could use to communicate. *The Timeless Way of Building* (Alexander et al., 1979) describes a theory and a process of building where the products that result from this process are of a particular quality: whole, alive and containing what Alexander refers to as the quality without a name (Alexander et al., 1977). The process Alexander describes was intended to

be used to apply a combination of the 253 patterns described in *A Pattern Language* (Alexander et al., 1977; Alexander et al., 1979). According to Alexander, a pattern describes: “a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice” (1977, p. x). Alexander’s patterns each contain the following elements: a name, a number, a picture, an introductory paragraph (sets the context and explains how the pattern helps complete larger patterns), three diamonds (beginning of the problem), headline (the essence of the problem), body of the problem, a solution, a diagram, three diamonds, and references to smaller patterns that are needed to complete a pattern. In *A Pattern Language*, each pattern is labelled (with asterisks) according to certainty or confidence in the solution. For several year Alexander and colleagues worked to document and validate the patterns in *A Pattern Language* (1977).

In the 1990s, the software engineering community began exploring the use of software design patterns to document quality solutions to software problems and also to promote the reuse of those solutions. *Design Patterns: Elements of Reusable Object-Oriented Software* by Gamma et al. (1994) is one of the most well-known works in this area. As the title of this book suggests reuse is one of the main motivations for using design patterns in software engineering. Interest in software design patterns has continued. In 2018, the well-attended Pattern Languages of Programs (PLoP) Conference was held for the twenty-fifth time. In HCI there have been several motivations for exploring pattern languages (Erickson, 2000; Fincher et al., 2003). The possible benefits or promises of pattern languages (Pemberton, 2000) have been discussed extensively. Reuse and quality are two of the main and most often cited reasons for the use of design patterns and pattern languages in HCI (Erickson, 2000). Some other possible benefits include: providing a lingua franca (Erickson, 2000), assisting in communicating solutions and the capture and sharing of design knowledge (Granlund, Lafreniere, and Carr, 2001), and bringing design and evaluation closer together (Mahemoff and Johnston, 1998). Similar to other design disciplines, in HCI we strive to design quality artifacts without reinventing the wheel. Design patterns and pattern languages address reuse and quality. In both HCI and architecture, a participatory design process has been explored. Design patterns and pattern languages have been used to facilitate this participatory process. Design patterns have been explored as both design and evaluation tools (Borchers, 2001; Cowley and Wesson, 2005; Mahemoff and Johnston, 1998; Wesson and Cowley, 2003). Cowley and Wesson (2005) compared guidelines and patterns as both design and evaluation tools. Their results suggest that designers considered patterns effective evaluation tools (Cowley and Wesson, 2005).

Although patterns have been documented and researched for years in HCI, there is no agreed upon definition of a pattern or a pattern language. There is also no agreement on the form of a pattern. As defined by van Duyne et al., patterns in HCI “communicate insights into design problems, capturing the essence of the problems and their solutions in a compact form. They describe the problem in depth, the rationale for the solution, how to apply the solution, and some of the trade-offs in applying the solution.” (2003, p. 19). Some common characteristics are seen in various definitions of a pattern (Wania and Atwood, 2009). In HCI, a pattern language, as described by Mahemoff and Johnson, is “formed when a collection of patterns is arranged into a network of interdependent patterns, especially where higher-level patterns yield contexts which are resolved by more detailed patterns.” (2001, p. 351). The concept of a pattern language is clear in Alexander’s work but, in HCI and other disciplines this concept is not reflected in all work. Problems with design patterns and pattern languages in HCI have also been identified including lack of a standard format, lack of an organizing principle, and the lack of empirical work (Borchers, 2000; Casaday, 1997; Todd et al., 2004; Welie and Veer, 2003).

Dearden and Finlay (2006) provide a critical review that includes benefits, problems and outlined a research agenda. Since their 2006 review, empirical work has continued in this area (Denef and Keyson, 2012; Hübscher et al. 2011; Janeiro et al. 2010; Pan and Stolerman, 2013; Petter, Khazanchi, and Murphy, 2010; Wania and Atwood, 2009), but more empirical work is necessary. Dearden and Finlay (2006) suggest a research agenda that includes exploring ways to use pattern languages in education. Borchers (2002), Koukouletsos et al. (2009), and others have explored using design patterns and pattern languages in education. Koukouletsos et al. (2009) used patterns and guidelines to teach novice designers about usability principles. Students then completed a design task using either patterns or guidelines. Students in the patterns group performed better on the design task, as rated by independent evaluators (Koukouletsos et al. 2009). Koukouletsos et al. (2009) conclude that patterns had a stronger impact. In this work we explore one way design patterns might be used as evaluation tools in HCI education.

EXPLORING DESIGN PATTERNS AS EVALUATION TOOLS IN AN ASSIGNMENT

College student perceptions of design patterns and heuristics were collected in fall 2018. Students were enrolled in a HCI elective at a liberal arts college. This course is offered by the Computing Sciences Department which has two ABET accredited programs: Computer Science and Computer Information Systems. There are approximately 250 majors in the department. Upper division elective enrollments generally range from 10-30 students. Students in this course are senior or junior students who have been exposed to some introductory HCI concepts in previous courses. This course covers topics

ranging from human memory and perception to Human Centered Design. There is a large team project in this course. The project begins in the third week and extends to the last week of the semester. Students use the Human Centered Design approach to design a website. As part of the team project students write scenarios, design paper prototypes, conduct a small usability study, and create high fidelity designs. Design patterns, guidelines and heuristics were discussed in class for more than 75 minutes prior to students receiving an assignment that explored the use of design patterns as evaluation tools. Examples of patterns, guidelines and heuristics were shown on existing websites and discussed in class. In this assignment students were asked to use a set of design patterns and a set of heuristics to evaluate low fidelity designs (paper prototypes). Nielsen's (1994) heuristics were chosen because they are very well known, highly cited and empirically validated heuristics. Welie's interaction design pattern library was chosen due to the breadth and depth of the patterns and because the patterns contain the essence of Alexander's patterns and a pattern language. As part of the assignment, students were asked about their general perceptions of the design patterns and heuristics.

Students completed an individual assignment that required them to use design patterns and heuristics to assist with the evaluation and redesign of websites designed by teams of four students in this course. The assignment was distributed in the 10th week of the semester and due in the 12th week of the semester. The assignment instructions were distributed in class and also posted on Blackboard. The instructor reviewed the assignment requirements in class and answered any questions regarding the assignment. The assignment instructions stated that students should briefly review the patterns in all sections of Welie's interaction design pattern library but focus more attention and time on the patterns in several specific areas including: navigating around, searching, personalizing and feedback. This was done for several reasons: so as not to overwhelm the students (Welie's pattern library contains more than 100 patterns), in order to reduce the scope to what was most appropriate for their designs, and in considering that the heuristics are very brief in comparison to Welie's patterns and pattern library. The assignment included hyperlinks to Welie's pattern library and to Nielsen's heuristics. The assignment instructed the students to review the design patterns and heuristics prior to answering any of the assignment questions. The assignment included 14 questions, 7 questions related to design patterns and 7 questions related to heuristics (noted as q1-q14 here). The assignment asked students to identify specific areas where they had already used a design pattern (q1) or heuristic (q8) and specific areas where they had violated a design pattern (q2) or heuristic (q9). The assignment also asked students to identify specific areas where a design pattern (q3) or heuristic (q10) had not been used, but could potentially be used. The assignment also asked students to identify any design issues that they may have noticed as a result of reviewing their paper prototypes using the design patterns (q4) and heuristics (q11). Students were then asked to respond to several statements using Likert type responses (strongly disagree, disagree, neither agree nor disagree, agree and strongly agree) about their perceptions of using design patterns (q5) and heuristics (q12). The assignment also asked students to reflect upon the process and describe any challenges, likes (q6, q13) and dislikes (q7, q14). The assignments were examined (not as part of the grading process) to identify the number of design patterns mentioned, the number of heuristics mentioned, number of usability problems identified and the number of potential improvements identified. After the assignments were returned to the students they reviewed the designs and the results of this evaluation in their project teams. This allowed them to share their findings with the team.

Six of eight students enrolled in this course completed the assignment in its entirety. Students' assignments ranged from 4 to 9 typed pages with an average of approximately 5 pages. Student responses to the questions varied. The first question (q1) asked students to identify and list specific areas where a pattern was used, specifically describe the area and identify the pattern used. Two students identified 5 patterns, two students identified 4 patterns and two students identified 3 patterns, for a total of 24 identified pattern occurrences. Of the 24 identified occurrences there were 14 unique patterns identified. That is, more than one student identified some of the same patterns. The 14 patterns included: advanced search, create account, customize window, icon menu, login, main navigation, map navigator, news site, panning navigator, registration, retractable menu, search area, search box and search results. The most frequently identified patterns included advanced search and login. The assignment also asked students to identify where a pattern was violated in the designs (q2). Students identified 21 occurrences in which the designs violated a pattern. Three students identified 4 pattern violations and three students identified 3 pattern violations. Of the 21 violations, there were 13 unique patterns identified including: action buttons, advanced search, forms, homepage, home link, icon menu, login, main navigation, map navigator, retractable menu, search box, search results, and send-a-friend link. In some cases when a student identified a pattern that was violated, they identified more than one usability issue. In total, students identified 23 usability problems using the design patterns. The assignment also asked students to identify where a pattern was not used, but could possibly be used (q3). Students identified 19 patterns that were not used, but could possibly be used in the designs. Two students identified 4 patterns that could possibly be applied, three students identified 3 patterns that could possibly be applied and one student identified 2 patterns that could possibly be applied. Of the 19 patterns identified for possible use, 11 unique patterns were mentioned. Five students identified that a footer sitemap was not used but could possibly be used. Three students identified that the autocomplete pattern could possibly be used. Two students identified that the frequently asked questions pattern could be used and two students

identified that the to-the-top pattern could be used. In some cases when discussing a pattern, a student identified more than one improvement that could be made. In their discussion of patterns that could be applied, students identified a total of 23 potential improvements. Students were also asked what they liked (q6) and disliked (q7) about using the patterns to evaluate the websites. All students had at least one positive remark about using the patterns. Examples include: 'It gives you concrete examples of what worked before,' 'it told me why you should do something, and how it benefits the user,' 'it's a great way to include a checklist and make sure that it's including very basic things.' Two students stated that there was not much that they disliked about using the patterns. Two students stated that they disliked finding pattern violations. Some of the other responses to this question included somewhat contradictory comments that patterns are too broad and patterns are too precise. One student was concerned about patterns suppressing creativity. The student stated 'The only part I disliked from using patterns was the suppression of creativity. Yes, there are specific way to design things, however if we stick to standard patterns how will people innovate and create new patterns?'

The assignment asked students to identify and list specific areas where a heuristic was used, specifically describe the area and identify the heuristic used (q8). Four students identified 3 heuristics and two students identified 2 heuristics. Four students identified recognition rather than recall, three identified aesthetic and minimalist design, three identified consistency and standards, two identified match between system and real world and visibility of system status and one student identified error prevention and user control and freedom. Seven unique heuristics were identified by the students, with a total of 16 occurrences of the heuristics. The assignment asked students to identify when a heuristic was violated (q9). Students identified 14 occurrences where a heuristic was violated. Seven unique heuristics were identified in the 14 occurrences. User control and freedom was the heuristic mentioned most. Five students identified violations of user control and freedom. Three students identified violations of help and documentation. Two students identified violations of visibility and system status. Aesthetic and minimalist design, error prevention, flexibility and efficiency of use, and recognition rather than recall were each identified once. In some cases when a student identified a heuristic that was violated, they identified more than one usability issue. Students identified a total of 14 usability problems using the heuristics. The assignment also asked students to identify where a heuristic was not used, but could possibly be used (q10). Students identified 14 occurrences in which 8 heuristics could possibly be used. Help and documentation was mentioned by 4 students. Two students mentioned help users recognize, diagnose and recover from errors, user control and freedom, and visibility of system status. Consistency and standards, error prevention, flexibility and efficiency of use, and recognition rather than recall where each identified once. In some cases when discussing a heuristic, a student identified more than one improvement that could be made. In their discussion of heuristics, students identified 17 potential improvements to be made.

Students were also asked what they liked (q13) and disliked (q14) about using the heuristics to evaluate the designs. All students had positive remarks about the heuristics. One student commented: 'Heuristics was particularly useful for the things that patterns did not cover. Things like recognition over recall, and minimalist designs were not considered while evaluating patterns. I particularly thought heuristics was less useful than patterns when evaluating, however I believe heuristics are half the website and patterns are the other half.' Another student commented: 'The heuristics made me think of some things that I paid no mind to, such as an emergency exit and documentation.' One student stated: 'There was not anything I disliked from using heuristics to evaluate. They still gave enough freedom to be creative, while guiding functionality in the right direction. Overall great tool for evaluating designs.' Three students mentioned things that they disliked. The comments indicated some confusion over particular heuristics and difficulty identify when a heuristic was or was not used. For example: 'I think they were very basic. Such as the heuristic flexibility and efficiency of use, what are possible examples of accelerators he was mentioning? It would be more helpful to have a picture or example.' Four of the six students indicated that they believed the patterns helped them evaluate the websites (q5). One student disagreed and one was not sure. Three of the six students agreed that they would use patterns in the future to evaluate website designs. Two were unsure and one disagreed. Only two of the six students expressed that they enjoyed using the patterns in their evaluations. Three students were unsure and one disagreed. For heuristics, four of the six students indicated that they believed the heuristics helped them evaluate the websites (q12). One student disagreed and one was not sure. Five of the students agreed that they would use heuristics in the future to evaluate website designs and one was unsure. Only two of the six students expressed that they enjoyed using the heuristics in their evaluations. Three were unsure and one disagreed. A brief discussion is included in the following section.

DISCUSSION

Dearden and Finlay (2006) in their review suggest a research agenda that includes exploring ways to use pattern languages in education. Here, we explored one possible way to use design patterns in HCI education. In this exploratory assignment using design patterns as evaluation tools, students identified 23 problems and 23 potential improvements in low fidelity designs. When using heuristics students identified 14 problems and 17 potential improvements. All students had some positive remarks about using both design patterns and heuristics as evaluation tools. Cowley and Wesson (2005) suggest that novice

designers considered patterns effective evaluation tools. The students in this course also appeared to appreciate and find value in using design patterns as evaluation tools. In this exploratory assignment, students identified more problems and potential improvements when using design patterns compared to heuristics. As mentioned by a student in this study, design patterns and heuristics are complementary. These are areas for further investigation.

CONCLUSION

Most of the students who completed this exploratory assignment using design patterns and heuristics as evaluation tools perceived that the design patterns and heuristics were helpful in evaluating the low-fidelity designs. Students identified more usability problems and suggested more usability improvements when using design patterns to evaluate the designs. Half of the students expressed interest in using design patterns as evaluation tools in the future and all but one student expressed interest in using heuristics as evaluation tools in the future. More work must be done to further explore and evaluate the impact of design patterns in HCI education, and the impact of design patterns as evaluation tools.

LIMITATIONS AND FUTURE WORK

The exploratory approach used in this work is one of many possible ways to explore the use of design patterns in education. There are several other ways to explore this question. The goals of this study were to explore how design patterns might be used in HCI education, to begin to explore how novice designers might use design patterns as evaluation tools and to gather perceptions of this process. The number of students who completed this exploratory assignment was small. We plan to further refine the process, the questions used to gather perceptions and then gather data from a larger group of novice designers.

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